8 March 1967

AUTOMATIC FOCUSING SYSTEM - STAFF STUDY

#02217

1. PROBLEM

To demonstrate the feasibility of automatically maintaining focus during the process of scanning film with rear projection systems.

2. FACTS BEARING ON THE PROBLEM

Improved resolution of acquisition materials requires higher magnification resulting in more critical focusing criteria for our optical reproduction and viewing equipment. Under these conditions optimum focus is difficult to achieve and maintain. A system is needed to automatically accomplish these operations. It appears that the remedy for this situation is within the capability of contemporary technology.

3. DISCUSSION

a. Current Procedures: The reproduction and viewing of high resolution imagery during the high priority OAK scanning operation is further complicated by this critical focusing requirement. It has not been practical to develop other means of automatically maintaining optimum focus while the film is in motion during the scanning process. Therefore, the photo interpreter's efficiency is significantly reduced by the constant requirement to perform tedious manual focus adjustments.

b. Origin of Concept: The feasibility of developing an automatic focusing technique which could be readily applied to various categories of optical equipment was studied under a previous contract. The conclusions of the study were that (1) automatic focusing was technically feasible and (2) an automatic focusing technique has been developed which is indeed applicable to many different types of optical devices.

c. Proposed Program: This is a TDS sponsored effort to yield a capability for automatic focusing which can be applied to enlargers, microscopic and rear projection viewers and comparators as needed. The proposed program is an immediate follow-on effort to the Automatic Focusing Feasibility Study. It will include the actual fabrication of an automatic focusing device as applied to a rear-screen projection unit. The demonstration model for this particular contract effort will be a breadboard configuration; it will not be designed or constructed as a prototype unit.

The major research and development efforts will be concentrated on the focus-detection optics, lens stereo system, and those characteristics of the film-drive system that contribute to the film-phase variation, thus causing the basic variation in focusing.

Three primary values of magnification will be selected for demonstration, 3X, 15X, and 70X to determine whether or not the automatic focusing system can be made to provide a useful range of automatic focus control from low to very high magnification values.

It is anticipated that the proposed task can be accomplished in six working months with an estimated cost [redacted] on a cost-plus-fixed-fee basis. 25X1

d. Selection of Contractors: Since this is a follow-on to a previous contract with [redacted] it would appear to be most beneficial to continue the project with the same technical staff that has been concerned with the project since its inception. As a consequence, [redacted] is recommended as the Contractor. 25X1 25X1

e. Coordination: There is no known equipment available or under development which will satisfy this requirement. This project has been coordinated with DD/S&T/ORD, disseminated to the Intelligence Community in the 1966 NPIC Equipment Summary, and presented to the Committee on Photographic Exploitation and representatives of the Army, Navy, and Air Force. The appropriate technical personnel of PAG, IAS/DDI, and TID have been briefed on this project.

f. Alternatives: There are no known devices, existent or under development, which will yield the results of the proposed project. Although there are commercial automatic focusing devices on the market, none are precise or versatile enough to meet the stringent requirements of NPIC's equipment.

4. CONCLUSIONS

Development of an automatic focusing system for the rear projection viewer is an important basic step in the evaluation of automatic focusing in general. The system can be modified to apply to other optical systems. This development if successful, will be utilized on our latest model rear projection viewer which is currently under development.

5. RECOMMENDATIONS

It is strongly recommended that approval be given to contract with Stanford Research Institute for a feasibility model of an automatic focusing system for rear projection at a funding level of [redacted] in FY 1967. 25X1

6. REFERENCES AND ATTACHMENTS

TAB A. Catalog Form
TAB B. Technical Specifications
Attachment:

25X1

R & D CATALOG FORM

DATE: 8 March 1967

1. PROJECT TITLE/CODE NAME: Automatic Focusing System

2. SHORT PROJECT DESCRIPTION: Fabrication of a feasibility model of an Automatic Focusing Device as applied to a rear projection viewer.

3. CONTRACTOR NAME

4. LOCATION OF CONTRACTOR

25X1

5. CLASS OF CONTRACTOR: Manufacturer

6. TYPE OF CONTRACT: CPFF

7. FUNDS: FY 1966 $ NONE

25X1 FY 1967

FY 1968 $ NONE

8. REQUISITION NO.: NA

9. BUDGET PROJECT NO.: NP-V-21-02217

10. EFFECTIVE CONTRACT DATE *(Begin - end)*: April 1967 - October 1967

11. SECURITY CLASS.: AA - Conf. T - Unclass. W - Unclass.

12. RESPONSIBLE DIRECTORATE/OFFICE/PROJECT OFFICER TELEPHONE EXTENSION

25X1 DDI/NPIC/TDS

13. REQUIREMENT/AUTHORITY

If the device to be fabricated proves successful, the basic principles will have application in any optical device that requires critical focus.

14. TYPE OF WORK TO BE DONE

Engineering Development

15. CATEGORIES OF EFFORT

MAJOR CATEGORY	SUB-CATEGORIES
Viewing Systems	Focusing Systems

16. END ITEM OR SERVICES FROM THIS CONTRACT/IMPROVEMENT OVER CURRENT SYSTEM, EQUIPMENT, ETC.

Feasibility model and final report. Current focusing systems are too costly and complex, lack precision, require periodic calibration, and cannot be applied to a variety of lens systems.

17. SUPPORTING OR RELATED CONTRACTS *(Agency & Other)*/COORDINATION There is no known equipment available or under development which will satisfy this requirement. This project has been coordinated with DD/S&T/ORD, disseminated to the Intelligence Community in the 1966 NPIC Equipment Summary, and presented to the Committee on Photographic Exploitation and representatives of the Army, Navy, and Air Force.

18. DESCRIPTION OF INTELLIGENCE REQUIREMENT AND DETAILED TECHNICAL DESCRIPTION OF PROJECT *(Continue on additional page if required)*

Automatic focusing will be an integral part of other programs under development; i.e., automatic stereo scanning and rear projection viewing. This project will investigate feasibility of automatic focusing applied to rear projection. A suitable technique has been selected, based upon results of previous investigation. In this approach, the object is imaged on the face of a wide-area, non-linear photocell which vibrates in the direction of the optical axis. By sensing the phase of the fundamental component in the output signal, and also certain harmonic content, it is possible to determine the state of focus/de-focus

19. APPROVED BY AND DATE

OFFICE	DEPUTY DIRECTOR	DDCI

TAB B

TECHNICAL SPECIFICATIONS FOR THE DEMONSTRATION UNIT

The following specifications are suggested for the demonstration unit. Minor variations in the details of the specifications, as deemed desirable by the project monitor and [redacted] project leader or as required by the availability of specific components, can be mutually agreed upon in the early phases of the work.

25X1

a. Film Drive: A motor-driven film drive will be designed to handle rolls of 9-inch-wide (aerial) film with manually adjusted film speeds from 0 to 2 inch/second. Provisions for higher film-drive speeds for slewing are not considered necessary.

b. Film-Projection Light Source: The light source for proper illumination of a 9 X 9 inch area of film is a major component. A suitable illumination source might be obtained from government-furnished equipment; alternatively, a suitable light source will be purchased and modified for the demonstration unit. It is suggested that the light source be in the range of 1 to 2 kw, which should provide a suitable image intensity for focus demonstration purposes; however, a light of this power probably will not give the image-brightness level desired for operational rear-screen-projection viewers.

c. Image Magnification: Two values of image magnification will be selected; e.g., 3X and 15X. Exact values will depend on the focal length of readily available precision projection lenses. These two values of magnification span the range of values that typically would be used in the scanning mode of operation where automatic focusing has had the greatest value. In addition, previous theoretical study has shown that the automatic-focusing technique is most readily applicable to this magnification range.

A third, higher value magnification (near 70X) will be included to determine whether or not the automatic focusing system can be made to provide a useful range of automatic focus control at high magnification values. This will permit a complete evaluation of the automatic focusing system over the range of practical magnifications.

The interchange of lenses required for the different magnifications will not be a simple operator adjustment on the proposed demonstration unit but will require the mechanical interchange of the selected lens and the possible relocation of certain components in the focus-detection optics.

d. Lens Servo System: A servo system will position the projection lens to give a sharply focused image of the film on the viewing screen. The servo will be controlled by signals from the focus-detection sensor. The amplitude and frequency response of the servo will be designed to move the lens such that a film deviation of ± 1/4 inch from the nominal film plane can be correctly focused on the screen. The frequency response of the servo will be initially designed to achieve a 10 c/s frequency response.

Measurements of the actual vibration frequencies and amplitudes of the film, when moving at various scanning speeds, will be required to determine what frequency response is actually required by the lens-focus servo system. Investigation of the dynamics of the film motion will be made to determine what techniques might be used to reduce both the frequency and amplitude of the film displacement, and how best to optimize the compromise between the amplitude and the frequency of the film displacement in relation to the lens servo characteristics.

e. Focus-Detection Subsystem: The focus-detection subsystem will project a special optical pattern onto the film and detect the focus of the reflected image of this pattern. The previous project developed the theory for this basic focus detection technique. The engineering application of this technique to a rear-screen projection viewer will be primary effort of this project.

Recent focus-detection work on a related project has extended this technique to permit the use of a transverse (rather than longitudinal) mode of motion for the focus-detection image. This mode eliminates the need for the vibrating pellicle mirror in the focus-detection optical system. This could simplify the optics and will thus be considered for application along with the basic longitudinal vibration mode.

18 August 1965

Objectives for an Automatic Focusing System

1. Resolution. Resolution sensitivity at the output presentation (the point that the original is examined by the eye) of greater than 10 line pairs per millimeter.

2. System Response. The system must sense, respond and correct--by changing the projection lens position--variations in the object plane position of up to $\pm\frac{1}{4}$". This must be accomplished ata rate faster than the response time of the eye.

3. Energy Required. The illumination required from the projected image should be a mimimum. The maximum illumination reduction should be 10%. This light subtraction technique (beam-splitter in projection path) is preferable over sensors in the image plane.

4. The system should be completely automatic; not requiring periodic calibration. The system should average any curvative in the objective plane; however, it should consider only that portion of the image which is actually being projected.

5. Magnification Ranges. The equipment that this device would be used on has a range of magnification from one to fifty diameters.

6. Equipment. This system is to be used on rear-projection viewers, photographic enlargers, direct viewing equipment, etc.